MOLECULE FORMATION AND STATE-CHANGING COLLISIONS OF SINGLE RYDBERG ATOMS IN A BEC

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A single Rydberg excitation in the high-density and low-temperature environment of a Bose-Einstein condensate (BEC) leads to a fascinating testbed of low-energy electron-neutral and ion-neutral scattering. In particular the small interparticle spacing in a BEC makes it possible to study the role of ion-neutral interactions in l-changing collisions on time scales much shorter than the Rydberg lifetime. We take advantage of the mean field density shift, caused by elastic electron-neutral collisions, to probe density dependent shells of the ^{87}Rb BEC and thereby measure the l-changing collision time versus density and principal quantum number. We report on l-changing collisions due to inelastic scattering of the Rydberg electron with a neutral atom located near the Rydberg ionic core. We measure timescales of both the l-changing collision and the Rb_2 molecule formation of less than one microsecond for $n < 100$ at the highest BEC densities. We extract a change in kinetic energy of the Rydberg atoms that matches well with the energy gap to the next-lowest manifold. We measure Rb_2 signal that decreases with increasing principal quantum number. The mechanism and timescales of the l-changing collision are compared with simulations including the motion of the ionic core and neutral atoms, as well as the Rydberg electron.